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## REPORT OF THE ENTOMOLOGIST.

UNITED STATES DEPARTMENT OF AGRICULTURE,  
BUREAU OF ENTOMOLOGY,  
Washington, D. C., August 8, 1914.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1914.

Respectfully,

L. O. HOWARD,

*Entomologist and Chief of Bureau.*

Hon. D. F. HOUSTON,  
*Secretary of Agriculture.*

### SUMMARY OF RESULTS OF NEW WORK AND OF PROGRESS IN THE OLDER INVESTIGATIONS.

#### WORK ON THE GIPSY AND BROWN-TAIL MOTHS.

In the 1913 report attention was called to important changes made in the organization of the work carried on against these insects under the direction of Mr. A. F. Burgess of this bureau. During the fiscal year just closed the work has been carried on along the lines laid down in that report. Several of the extensive experimental projects are nearing completion, and good progress has been made in further colonizing and determining the spread of the parasites and natural enemies introduced from Europe and other countries.

*Progress of the gipsy moth in New England.*—The extensive scouting work which has been carried on during the year around the borders of the infested region has resulted in the discovery of the gipsy moth in 81 towns in Maine, 6 in New Hampshire, 7 in Massachusetts, 17 in Rhode Island, and 7 in Connecticut, in none of which the moth had been previously reported. Eight towns, however, inside the infested area were thoroughly examined and no moths were found. The winter of 1913-14 was one of the coldest which New England has had for many years, and it was impossible to carry on as much scouting work as had been planned. Several isolated colonies in Greenfield, Mass., were examined, and appear to have been exterminated. The somewhat isolated infestation in the region of the towns of Lenox, Stockbridge, and Great Barrington has been thoroughly scouted, and the moths seem to have been nearly exterminated in this region. The isolated colony at Wallingford, Conn., has apparently been exterminated. At Stonington in the same State a few egg clusters were found, and this locality is being cared for by the State.

*Gipsy moth in Ohio.*—In February gipsy moth egg clusters were found in Bratenahl, a suburb of Cleveland, Ohio, and several men were detailed to scout the estate and surrounding territory. The State nursery inspector of Ohio and the president of the Ohio Agricultural Commission were consulted, and through their efforts very thorough work was carried on to wipe out this colony.

*Gipsy moth in New York.*—The colony mentioned in the last report at Geneva, N. Y., has evidently been exterminated. In May a colony of gipsy moths was found on a large estate at Mount Kisco, N. Y. Steps were immediately taken to cooperate with the New York State authorities in stamping out this outbreak. Apparently

this colony was of several years' standing; but the New York authorities appreciate the seriousness of the situation, and such good cooperative work has been carried on that there is every hope that the colony will be exterminated.

*Need of amended State laws.*—In several of the infested States the whole expenditure in control of moths is made by the State, and this becomes inadequate as the number of infestations increases. State laws drawn in general conformity with the present law in Massachusetts, requiring that each municipality do its share toward controlling the moths, would greatly assist in the difficult problem of preventing westward spread.

*The brown-tail moth situation.*—The brown-tail moth situation has changed materially during the year. The severe winter, coupled with the beneficial work of the brown-tail moth fungous disease and the imported parasites, has resulted in an enormous decrease. This decrease has been generally noticeable, especially in the northern part of the infested region in Maine, New Hampshire, and Vermont. Through the efforts of the New York State inspection service, brown-tail moth nests have been found in several localities on the eastern end of Long Island.

*Quarantine work.*—The inspection of all forest products and nursery stock moved from the gipsy moth and brown-tail moth regions to other parts of the United States has been carried on continuously and systematically throughout the year. The territory has been divided into districts and an inspector assigned to work in each. His efforts from time to time have been supplemented by extra assistants. This work has undoubtedly prevented the establishment of many colonies in widely separated localities. Seventeen thousand and seventy-six shipments have been inspected and 4,253 specimens of the gipsy moth and 1,404 specimens of the brown-tail moth have been found and destroyed. If this work had been begun years before, the small colonies in New York, Ohio, and the Berkshire region in Massachusetts would not have become established.

*Silvicultural work.*—The silvicultural work which was begun last year in connection with the Forest Service has been continued throughout the year. Twenty-nine sample plats have been selected in Maine, New Hampshire, and Massachusetts, and thinned in such a manner as to put them in the best silvicultural condition.

*Experimental work.*—Experimental work on the food plants and feeding habits of the gipsy moth under laboratory and field conditions, together with the more important project of securing more definite data on the actual increase of the moth under field conditions, food plants being considered, has been continued and will be completed by the end of the next fiscal year.

Studies on the wilt disease of the gipsy moth have been continued.

Experiments on the dispersion of gipsy moth caterpillars by the wind have been continued on a large scale.

Studies have also been made of the work of one of the secondary insects which attack injured oak trees, this work being carried on in cooperation by the branch of Gipsy and Brown-Tail Moth Investigations and the branch of Forest Insect Investigations of this bureau.

*Introduced parasites and natural enemies.*—The introduced parasites of the gipsy moth and the brown-tail moth have been more abundant and conspicuous in their work during the year than ever



before. The two species of egg parasites, *Anastatus bifasciatus* and *Schedius kuvanae*, have been recovered in good numbers. From collections made in the fall of 1913, 67,600 specimens of the former have been colonized in 18 towns, and the species has been recorded from 16 new localities. At the present time this parasite is known to be present in 41 towns, and in many places the percentage of parasitism has been rather high. Commonly, 25 per cent of the eggs in clusters have been destroyed by this parasite, and in one case the percentage has run as high as 43.7. In the spring of 1914, 1,561 new colonies of this parasite were liberated in New Hampshire and Massachusetts, totaling 1,561,000 specimens.

Four other hymenopterous parasites, namely, *Apanteles lacteicolor*, *Meteorus versicolor*, *Limnerium disparis*, and *Apanteles melanocelis*, are evidently well established.

The tachinid fly, *Compsilura concinnata*, has been markedly in evidence, especially in some sections slightly infested by the gipsy moth.

The calosoma beetle, *Calosoma sycophanta*, was found abundantly in very many localities during the spring of 1914. Scouting work the preceding summer indicated that it had spread over a much wider area than heretofore. The beetle is large and conspicuous, and there is no doubt as to its great value as a destroyer of gipsy moth caterpillars and pupæ.

*General conditions.*—The results of the work during the year have been very encouraging. There is obviously a marked decrease in the numbers of both gipsy and brown-tail moths. The wilt disease and the introduced parasites and beetles have been largely instrumental in bringing about this condition. The entire work, both field and experimental, is showing good results.

Colored posters have been prepared illustrating the gipsy moth and its natural enemies, which have been posted in all the post offices and town offices in the infested district, and copies have been sent to granges and public libraries. Post cards bearing the same illustrations have been distributed by mail and by the Boy Scouts.

#### DECIDUOUS FRUIT INSECT INVESTIGATIONS.

Mr. A. L. Quaintance remains in immediate charge of the bureau's investigations of deciduous fruit insects. The work as a whole has been a continuation of projects under way during the fiscal year 1913, certain of which have been completed, and a few new ones have been begun.

*Apple-insect investigations.*—Special attention has been paid to apple-tree borers, especially the roundheaded apple-tree borer, the biology of which has been fairly well worked out. The insect has been found to breed in large numbers in the service berry. It is being studied in typical orchard sections, and by thorough removal of the insect from the orchards and the destruction of its native food plants rather good control seems possible.

The studies of the woolly aphids of the apple have been completed and a report is now in press. Confirming work of other investigators, this insect has been found to winter on elms, on which migrating individuals are developed in the spring and make their way to the apple. This information will be of material value in the control of the insect on apple, especially on apple nursery stock and in newly planted orchards. It appears that the remedies adopted in certain European countries in the control of the grape *Phylloxera* should

be effective in the destruction of the root form of the woolly aphis. This idea is now being investigated.

Other plant-lice affecting the apple are being studied, especially the so-called rosy apple aphis, which is the cause in some seasons of very severe losses to apple growers. It has been found that effective control work may be accomplished by a single application of a suitable contact spray shortly after the leaves have appeared and before the blossom buds are exposed to any extent.

The work on the codling moth, covering sections of the country not hitherto studied in the comprehensive plan of work against this insect, has been continued. Life-history investigations have been carried on in Maine, and spray testing in orchards has been undertaken in the Pecos Valley of New Mexico. The studies of this insect in the Alleghany region have been completed.

The affection of apples known as stigmonose is the cause of frequent complaint from apple growers. As this trouble may result from the punctures of the fruit by plant-bugs and plant-lice, the bureau has undertaken, in cooperation with the Bureau of Plant Industry, an investigation of this trouble, with headquarters at Wenatchee, Wash.

*Peach-insect investigations.*—Additional studies of the peach-tree borer were made during the spring of 1913, especial attention being given to the possible value of applications of protective washes.

Investigations of the peach lecanium were completed at the close of the season of 1913. A detailed knowledge of the life history, habits, and insect enemies of the pest has been gained, and an effective remedy in the shape of a mineral-oil spray, applied to the trees in the spring before the opening of the buds, has been found.

*Pear-thrips investigations.*—The pear thrips, an extremely destructive pest, which made its first appearance in portions of California, is now under virtual control by means of spraying formulas developed by the work of the bureau. The general adoption by the orchardists of the bureau's spray formulas, and their increasing familiarity with the details of pear-thrips control, have proceeded so far that future work against this insect may be greatly reduced, if not discontinued. This insect, however, has become established in several orchard regions in the East. Its general spread throughout the East is probable, and, although the best spraying mixtures have been discovered, their use will be an added expense to eastern growers.

*Grape-insect investigations.*—It is hoped that the biological studies of the grape *Phylloxera* in California will be completed by the close of the season 1914. The work of renovating old vineyards infested by this pest—that is to say, maintaining the vine in a thrifty condition in spite of the *Phylloxera*—gives promise of valuable results.

The investigations of the grape-berry moth, under way for several years and materially reduced in scope in 1913, were enlarged in the spring of 1914 at the request of grape growers in the Erie grape belt, where the pest continues to be a serious menace. The work as planned is proceeding along two lines—experiments in vineyards to determine the effectiveness of various local methods of control, and the investigation of the parasites of the insect with a view to their propagation and dissemination. An effort will also be made to introduce from Europe certain parasites of near relatives of the grape-berry moth.



*Nut-insect investigations.*—The studies of pecan insects, under way during the fiscal year ended June 30, 1913, have been enlarged. Experiments in the use of sprays in pecan orchards have been carried out in cooperation with interested growers, and show the effectiveness and practicability of this work.

*Investigations of orchard insecticides and spraying machinery.*—Tests in orchards on a commercial scale of numerous proprietary preparations have been made, and new sprays have been developed and are being tested for the control of scale insects, the codling moth, and other orchard pests. The "three-in-one" spray, mentioned in the last report, and composed of lime-sulphur, arsenate of lead, and nicotine, is being adopted by many orchardists for the control of biting and sucking insects and of fungous diseases as well.

*Cranberry insects in New Jersey.*—The work on cranberry insects in New Jersey is being continued, with hope of success. Attention is being paid to the simplification of the methods of preparing and using arsenical sprays in cranberry bogs, and this work promises a considerable reduction in the cost of materials and of spraying.

#### SOUTHERN FIELD-CROP INSECT INVESTIGATIONS.

Mr. W. D. Hunter has remained in charge of the branch of Southern Field-Crop Insect Investigations, with Mr. George D. Smith in charge of the cotton-boll weevil laboratory at Tallulah, La.

*Cotton-boll weevil.*—The work of the Delta boll-weevil laboratory, at Tallulah, consisted of practical field experiments in the use of powdered ortho-arsenate of lead, hand picking of cotton squares and bolls, and other experiments looking toward control.

The experiments with arsenate of lead as a means of destroying the weevils on the cotton in the early part of the season were conducted with varying results. Grouping these experiments with those of previous years gives a total of 89 experiments, which have shown an average net gain of \$1.86 per acre for the total acreage poisoned over the total acreage unpoisoned. The most uniform gains in production were with from one to four applications, at four to seven day intervals, on Cook's Improved, Blanchard, Foster, and Allen's Long Staple varieties. The question of the extent to which benefits from the use of powdered arsenate of lead may be obtained under practical plantation conditions remains undecided.

Experiments to determine the exact conditions under which the hand picking of cotton squares is practicable were conducted at two points in Louisiana and one in Mississippi. The interval between the pickings varied from 5 to 10 days. All of the squares were examined in the laboratory, and the exact causes of their falling were determined. One of the most interesting results was that the number of squares that fall after July 20 is double the number falling before that time. This shows the great importance of early rather than late work in the fields. The results of the experiments were extremely suggestive, but further investigation is required before specific recommendations regarding the details of square picking can be made.

Many observations were made during the season of 1913 of early and late planted fields in Louisiana and Mississippi. In the vicinity of Opelousas the average yield, for the farms investigated, of seed cotton per acre on fields planted before May 10 was 942 pounds, and for fields planted after May 10 was only 395 pounds.

Records of the hibernation of the weevil in Spanish moss in January, 1914, made at 12 localities in Mississippi and Louisiana, gave an average of 1,200 live weevils per ton of moss. This high percentage indicates severe damage during 1914 in this region.

Life-history investigations conducted at Victoria, Tex., during the summer of 1913 have proved that the boll weevil has not only changed somewhat structurally since entering the United States, but has become adapted to greater severities of climate and is also now able to obtain subsistence and possibly to develop on certain plants related to cotton, among which are *Hibiscus syriacus* and *Callirrhoe involu-crata*.

The discovery of the boll weevil in certain mountain canyons in Arizona, on the so-called Arizona wild cotton, *Thurberia thespesioides*, was followed up by exploratory trips in August and December, 1913, by rearing work throughout the summer of 1913, and by the stationing of an agent in Arizona in the spring of 1914. This western form of the species has shown an even greater adaptivity to climatic extremes than the eastern cotton weevil, and causes considerable fear for the success of western cotton growing.

The dispersion of the boll weevil was carefully mapped during the fall of 1913 in order to aid the various States in maintaining their quarantines. It was determined that 17,700 square miles of new territory became infested during the year. It is estimated that the primary loss in production of the area planted in cotton in 1913 occasioned by the boll weevil was approximately \$30,000,000.

*Other cotton insects.*—The cotton red spider work in South Carolina was continued. The control measures recommended as a result of this work include the destruction of winter food plants, destruction of weeds, such as pokeweed and violets, around the fields, destruction of isolated infestations, plowing of wide dust barriers around isolated infestations, and spraying with potassium sulphid.

An outbreak of the false chinch bug, *Nysius strigosus*, on cotton at Victoria, Tex., resulted in the discovery of a very efficient insecticide, consisting of the liquid obtained by precipitating potassium arsenate in solution with lime.

*Tobacco insects.*—The work at Clarksville, Tenn., dealt principally with the tobacco hornworms and miscellaneous insects affecting tobacco.

Powdered arsenate of lead, which has been found to be an insecticide that does not injure the dark tobacco, was tested under field conditions of great variability, and these tests confirmed the opinion that it is a safe remedy for use against the tobacco worm.

A study of the hibernation quarters of the tobacco flea-beetle has demonstrated that it shows a decided preference for certain types of cover. It was also determined that the larvæ are capable of doing great damage to infested plants. Careful studies of its spring feeding habits have been made in the effort to determine the advisability of destroying the host plants.

The work upon the cigarette beetle was conducted mainly at Richmond, Va. The effect of low temperatures upon the different stages of the insect has been worked out, and it was found that all stages of the insect can be killed very economically indeed by this method. The proper method of handling the tobacco to prevent damage during the change in temperatures remains to be worked out. Ammonia



gas also promises to be a very cheap and efficient remedy for the destruction of this pest.

Paris green mixed with corn meal has been used solely as a remedy for tobacco budworms in the Florida shade-grown tobacco districts. Owing to the free arsenious acid in the Paris green this method is very dangerous in rainy weather, and the efforts of the agent of this bureau now stationed at that place have been concentrated upon the problem of obtaining a combination of insecticide and carrier that will not damage the tobacco. Antimony sulphid, arsenate of lead, and tripotassium arsenate have given very promising results.

*Sugar-cane insects.*—A survey of the sugar-cane insects throughout the United States, conducted during 1913, emphasized the fact that the principal distribution of sugar-cane insects is through the shipment of planting cane, and showed clearly the necessity for greater care in selecting and shipping seed cane.

*Rice insects.*—The control experiments conducted against the rice water weevil at Crowley, La., indicated success from a two weeks' draining begun about three weeks after the first flooding of the rice.

*Argentine ant.*—The work with the Argentine ant at Hattiesburg, Miss., and New Orleans, La., has demonstrated the utility of sodium arsenate in sweetened solutions as a control measure, provided certain supplementary means are practiced.

#### INVESTIGATIONS OF INSECTS AFFECTING THE HEALTH OF MAN AND ANIMALS.

The investigation of insects affecting the health of man and animals consisted of studies of malaria prophylaxis, control of house flies in manure, eradication of the Rocky Mountain spotted-fever tick, the possible rôle of insects in the transmission of pellagra, tick life histories, and studies of insects affecting live stock.

An important line of new work undertaken by the bureau was a study of malaria-bearing mosquitoes. The object of the investigation was to obtain exact information on the relation of malaria to agriculture, on the bionomics of the mosquitoes involved in the transmission of the disease, and on prophylactic measures from the standpoint of mosquito control. Very favorable opportunities for the undertaking of this study were found on a large plantation in Madison Parish, La. Through the hearty cooperation of the management of the property and the plantation physician it was possible to obtain much definite information. An intensive study was made of 12 families, cultivating 246 acres of land. These families lost 88 weeks during the crop season from May to October, an average per family of over 7 weeks. Each family cultivated an average of 20 acres of land, a reduction by about 15 per cent of the acreage that could have been cultivated if it had not been for the low efficiency due to malaria. The figures indicate that if this loss were prevented there would be an increased income of \$24 per family, and that 57 families without malaria could have maintained the same production on the plantation as did 64 families. It is clear from these figures that the present loss through malaria in the Southern States runs into many millions of dollars.

An interesting feature of the investigation was the connection that was revealed between the malaria problem and the boll weevil. Under normal conditions a loss of time is not a very serious matter, if it occurs between the time the cotton crop is made and the time of picking. Under boll-weevil conditions, however, both the loss of

time and the decreased efficiency become more serious throughout the season. Failure to keep up the cultivation of the crop or to plant at the proper time gives the weevil a decided advantage.

An investigation of the means of controlling house flies by treating manure in such a way as not to injure its fertilizing value was conducted in cooperation with the Bureaus of Chemistry and Plant Industry. As a result of this work it was found that the house fly can be almost completely controlled, and the manure uninjured, by the application of commercial borax at the rate of 0.62 pound, or of calcined colemanite at the rate of 0.75 pound, to 10 cubic feet (8 bushels) of manure. The work on the life history of the fly revealed a migratory habit of the larva, which suggests forms of traps from which manure may be freed of maggots without the application of chemicals.

The eradication of the Rocky Mountain spotted-fever tick in the Bitter Root Valley, Mont., was actively begun in July, 1913.

The investigation of the possible transmission by insects of pellagra was continued in cooperation with the Thompson-McFadden Commission, with field headquarters at Spartanburg, S. C. It now seems unlikely that a blood-sucking insect can have any important relation to pellagra. If an insect is concerned it is much more likely to be the house fly, which may cause the contamination of food after contact with sewage. However, the work on biting insects was continued, and included transmission experiments, with negative results.

The investigation of flies, the larvæ of which attack domestic animals as well as man, was conducted throughout the fiscal year. One of these insects is the screw-worm, which, on account of its constant presence in injurious numbers in the southwestern portions of the United States, has come to be looked upon by stockmen as a necessary evil.

An investigation was carried on, first to determine the species of flies responsible, and, second, to study the biologies of the species concerned, with a view to determining feasible control measures. Contrary to the usual belief, the screw-worm fly, *Paralucilia macellaria*, is not the only species concerned. Three or more other species play an important part in the injury to live stock. The life and seasonal histories of these have been followed out rather completely.

It was found that all of the injurious species breed extensively in carcasses. Looking toward practicable preventive measures, experiments have been inaugurated to determine the effect of burial and of chemical treatment of carcasses on the prevention of fly breeding.

In view of the continued spread of anthrax in southwestern Texas and the probable part which biting flies, especially Tabanidæ, play in the conveyance of the disease from sick to healthy animals, an investigation of this question seemed important. This disease was especially severe during the summer of 1913, and horseflies were unusually abundant. A preliminary survey of parts of the infested territory was undertaken during the late summer and fall of 1913.

The announcement by Dr. C. Gordon Hewitt, head of the Canadian entomological service, of the wide distribution of the European ox warble, *Hypoderma bovis*, in Canada indicated the importance of determining the status of this warble in the United States. Extensive collections of larvæ, through correspondence, to determine this point, were therefore begun. Investigations were also started



to determine more accurately the seasonal history of the ox warble, *Hypoderma lineata*, with a view to suggesting improved methods of suppression.

Some further facts regarding the biology of the stable fly were determined. In tests of the method of hibernation it was found that all adults emerging in the fall succumbed early in the winter. The immature stages continued to develop and produced adults at intervals during the winter, some emerging late in the spring. This indicates the importance of giving proper attention to the destruction of breeding places during the winter months.

Observations have been made during the year to determine the relation of breed and color of cattle to horn-fly attack, and observations have been made upon natural enemies of the pest. Some exportations to Porto Rico of dung-inhabiting beetles, known to aid in reducing the number of horn flies, have been made. These reached the Porto Rican authorities in good condition and give promise of helping control the apparently recently introduced pest there.

Further experiments were made during the year on the relation of the cattle tick to its host, and to climatic factors known to aid in its control in nature. Some work was done at Dallas, Tex., on the effect of dips on the spotted-fever tick, cattle tick, and other important species.

The feasibility of utilizing a tick parasite, which occurs commonly in France, in the fight against the spotted-fever tick of the United States, has been pointed out by Dr. Brumpt, of Paris. Through his kindness two shipments of parasitized ticks were received and utilized in laboratory experiments.

#### CEREAL AND FORAGE INSECT INVESTIGATIONS.

Work on cereal and forage insects is being carried on under the direction of Mr. F. M. Webster. Many of the insects concerned in these investigations are widespread and must be studied in different parts of the country, since life histories and consequent measures of control must vary to some extent in accordance with climatic variations. For the purpose of studying these widespread species a belt of 15 field laboratories has been established. Important investigations, however, are being carried on concerning species as yet of limited distribution, and prominent among these are the following:

*The alfalfa weevil.*—Investigations on the important imported alfalfa weevil have been carried on continuously throughout the fiscal year. It has been determined that brush dragging, or the use of an ordinary spike-toothed harrow, with the teeth laid flat, and several layers of open wire fencing stretched beneath is, perhaps, the most easily made and efficient tool that can be used in the fields after the first crop has been removed. Moreover, the use of such a harrow stimulates the growth of the next crop. Valuable results have been obtained from pasturing by hogs during the egg-laying season of the weevil, and practical methods have also been found of poisoning the larvæ in the fields. A spraying method has been developed by which it is possible to protect the first and second crops by a single economical treatment in the early spring.

It has been found that one of the parasites introduced from Europe has established itself in the vicinity of Salt Lake City, and in one field a parasitism of 25 per cent has been found.

The weevil has not spread greatly, but a constant search is being made for indications of spread, and neighboring States are on the alert.

*The range caterpillar.*—Another of the regional projects that are being carried out is the investigation of the range caterpillar. A field station has been established in the midst of a 100,000-acre cattle range near Koehler, N. Mex. While a number of experiments were carried on with mechanical measures for destroying the caterpillars, it was seen from the beginning that these could not be made of any great practical utility, on account of the wide range of the pest and the diverse topography of the country. For this reason studies have been made of the local parasites and predaceous enemies, and importations have been made of natural enemies which might prove valuable in destroying the caterpillars. Moreover, two species which had been imported from Europe in the gipsy-moth work were collected in New England and sent to the New Mexico camp. A number of these natural enemies have been colonized at different points. It now seems that some of these introductions can easily withstand the climate of the New Mexico plateau and will readily destroy the caterpillars. An assistant of the Bureau of Biological Survey detailed to study the vertebrate enemies of the caterpillar found that skunks destroy myriads of the pupæ.

*Insects of wide distribution.*—During the year an outbreak of the so-called green bug was threatened in the southern Atlantic region. Owing to weather conditions that enabled the parasites to increase sufficiently, however, this did not prove serious.

Much consternation was caused in late winter by the swarming of the oat aphid in the wheat fields of northern Texas, but the same species of parasite which destroys the so-called green bug became so numerous as to hold the oat aphid in check. It is now evident that it will be necessary for the bureau to exercise a continual surveillance over the southern region, and it is also becoming evident that if a threatened outbreak can be suppressed over two very small areas little damage will occur northward.

Investigations of the jointworm, of the Hessian fly, of white grubs, of wireworms, of the corn leaf-aphid, of the clover stem-borer, of the fall army worm, of the lesser cornstalk borer, and others have been continued at the chain of stations mentioned.

*Grasshoppers.*—Grasshoppers of different species have been extremely abundant during the fiscal year. Cooperating with the State of Kansas, the bureau was able to assist in carrying out a State-wide war against these pests. The State organized counties in this work, the county furnishing the material for what is known as the poisoned bran bait for the farmers to apply. Most gratifying results were reached by the use of this poison.

An investigation was made of the grasshoppers of the Merrimac Valley in New Hampshire, which will be continued in the hope that we may be able to furnish farmers in that section with information that will aid them in protecting their crops.

*Other alfalfa insects.*—The clover and alfalfa seed chalcis is being studied most successfully by an expert in southern California, and he has accumulated data which will be of great assistance to the growers of alfalfa seed. The same insect affects the clover seed, and an outbreak of the clover flower midge has developed in Oregon. This insect also is a serious enemy of the seed crop. Experiments



carried on during the present summer in the harvesting of the first crop have shown remarkable results and bid fair to indicate means of almost complete protection to the seed crop.

A new pest to alfalfa, a native weevil known as *Compsus auricephalus*, has developed this year in Oklahoma. It does some damage to alfalfa and also to growing wheat. The life history of this insect has been carefully studied.

#### INVESTIGATIONS OF INSECTS INJURING FORESTS.

The work on forest insects has continued throughout the year under the supervision of Dr. A. D. Hopkins, and with few exceptions at field stations which cover a large share of the western forested regions, the only eastern station being located at East Falls Church, Va. A great deal of very important work has been carried on during the year.

*Demonstration of control methods against the Dendroctonus bark-beetles.*—The fiscal year just closed marks the culmination of the work which has been done toward the control of the very dangerous barkbeetles of the genus *Dendroctonus*, so injurious to conifers in different parts of the country. The final examination of the principal control areas from two to eight years after the control work was done has completely established the practicability of the bureau's methods. The first cost should rarely if ever exceed the stumpage value of the infested timber. If treated timber can not be utilized and must be left to decay, the value of the timber protected by the operation and which would otherwise have died within the next year or two will more than balance the first cost; so that continued protection will represent a cumulative profit.

Work of this character has been carried on by the Forest Service along the lines laid down by the Bureau of Entomology, upon forest reservations, with most gratifying success, while other work carried on by private owners and by railroads and on the Indian reservations under directions from this bureau has been equally successful.

In all of this work the percentage principle of insect control has been applied. This means that in order to protect a forest by no means all of the infested trees must be felled or barked. To treat 75 per cent of those infested will be ample, and in some cases this percentage may be greatly reduced. From 25 to 75 per cent of the infested trees must be disposed of, leaving the remainder of the infested trees to be cleared of barkbeetles by parasitic and predaceous insects, birds, diseases, and so on. This is really an extraordinary discovery and greatly simplifies control work and also greatly lessens its cost.

*Interrelation of insects and forest fires in the destruction of forests.*—Special investigations show (a) that insects are the most important factors in producing favorable conditions for the more serious forest fires; (b) that *Dendroctonus* beetles kill and are the direct cause of the death of more timber than is caused directly by forest fires; (c) that the control of *Dendroctonus* beetles would reduce to a very great extent the cost of the control or prevention of forest fires, while on the other hand forest fires contribute very little to the spread of destructive outbreaks of tree-killing insects.

*Agilus beetles in their relation to forest growth.*—It has been shown that while *Agilus bilineatus* is not as important as a primary enemy of healthy trees as has hitherto been supposed, it is of far

greater importance as a secondary enemy of oak and chestnut trees which have been weakened by defoliation or disease than had ever been suspected. This discovery is of great importance in the mixed forests of New England, which have been defoliated by the gipsy moth and the brown-tail moth. Additional information gained in regard to the seasonal history and habits of this beetle has enabled the forest insect branch of this bureau to recommend practical means of control at a minimum cost.

*Relation of mistletoe on living trees to attacks by insects.*—It has been claimed that a weakened condition of the coniferous trees of the Pacific and Rocky Mountain States offers favorable conditions for attack by *Dendroctonus* and other bark-boring beetles, and that mistletoe-infested trees lead to such destructive attack. Special investigations during the year, however, indicate that there is no basis for such a claim. On the contrary, it has been shown that trees upon which mistletoe is excessively abundant are less liable to attack by destructive insect enemies than are healthy trees.

*Insect damage to forest products.*—Investigations in search of remedies for insects which damage forest products have been mainly along the line of experiments with wood preservatives and treatments of different kinds of seasoned and unseasoned wood. Experiments have also been made with various species of seasoned untreated wood to determine their relative immunity and resistance against attack by white ants, or termites. The effective and economical preservatives and treatments have thus been separated from a mass of worthless or expensive ones. Some of the results reached are being put to a practical test by users of telegraph and telephone poles, railroad ties, mine props, and similar unseasoned products, and also by makers of cabinet work, tool handles, and vehicles. With hardwood products liable to attack by the so-called powderpost beetles it has been found that kerosene and linseed oil are effective repellents against these insects. A rather general utilization of these oils by manufacturers has followed this discovery.

*Laboratory investigations.*—A very large amount of work has been done in the laboratory over the whole field of forest insects. The work is effectively organized, and through its labors the bureau is enabled to give advice concerning practically all of the insects which damage forest trees.

#### INVESTIGATIONS OF INSECTS INJURIOUS TO VEGETABLE AND TRUCK CROPS.

Dr. F. H. Chittenden remains in charge of the investigation of vegetable and truck-crop insects. The principal work done during the year has been upon insects affecting potatoes, sugar beets, onions, and crucifers.

*Potato insects.*—The largest problem which has engaged the attention of the experts of this branch has been the potato tuber moth. The insect seems to be spreading, and is now known rather generally throughout southern California, and extends in occasional spots as far north as Shasta County. It has been found in one county in Utah, four counties in Texas, one in Louisiana, and one in Florida. Moreover, its occurrence is suspected in the State of Washington, in northern Kansas, and at one locality in Minnesota. Strong efforts have been made to warn potato growers of the seriousness of this pest and of the necessity for the rather simple protective and defensive measures.



New insecticides against the Colorado potato beetle and new sprayers for insecticide work against this insect have been studied.

The potato flea-beetle has received much attention, especially on Long Island, this project being now practically completed. Many insecticides have been tried against this pest, and the especially valuable ones act more as deterrents than as destroyers.

*Sugar-beet insects.*—Continuous work has been done on various sugar-beet pests, and the results are being published as the projects are nearing completion.

*Insects affecting cruciferous plants.*—The cabbage looper has been under continuous observation and a full report is nearly ready.

*Onion insects.*—The work on the onion thrips has been continued, and it has been shown that it can be controlled by nicotine sprays in combinations. Better machinery for spraying has been devised.

*Other vegetable, truck, and garden insects.*—A group of very important pests which have been investigated are the various root maggots which attack cruciferous crops, onions, sweet corn, and root crops generally. Control of these pests is very difficult and is requiring much study. More or less attention has been given to the study of the tomato fruit worm, or corn-ear worm, a very destructive pest which attacks a variety of plants. It has thus far defied all attempts at complete control, although it has been the subject of experiment for nearly half a century.

Practical work on the cutworms which affect garden crops has been carried on in nearly all of the stations of this branch of the bureau, with excellent results in all cases.

Much experimental work has been done with insecticides. Nicotine sulphate has been studied with a view to its standardization for different insects. . Flour paste has been discovered to be an excellent spreader of insecticide washes. Arsenite of zinc has been tested with good results against a variety of insects.

Much work has also been done with different insecticide distributors for use in truck fields. Because of the difficulty experienced with the heavy draft of horse-drawn vehicles using traction as power for the pump, experiments have been made with light high-speed gasoline engines. A horse-drawn sprayer of this type was devised, and it is doing effective work on Long Island. Another adaptation of this type of sprayer is in use at Garden City, Kans., and another one, self-propelled, will soon be available for use in the onion fields in Texas and Louisiana, where such a machine has long been a necessity for the control of the onion thrips.

#### INVESTIGATIONS OF INSECTS AFFECTING STORED PRODUCTS.

Work on stored-product insects, which include those affecting stored grain, flour, meal, prepared cereals, dried fruits, beans, peas, and other seeds, meats, cheese, fabrics, and other vegetable and animal matter kept in storage, has been continued, as in previous years, under the direction of Dr. F. H. Chittenden. Improved applications of the known remedies have been made, and new methods have been tried out. Insect-proof cartons for cereals and dried fruits have been invented, and methods of sterilization of mill products have been investigated. A publication on the insect-proof carton has been issued.

As a new project during the year, a preliminary examination has been made of Argentine corn, from the entomological standpoint, with especial reference to what is generally called in the trade "the

Argentine corn weevil." This term proves to include several different species, mainly the rice weevil, or corn weevil of the South, the Angoumois grain moth, and the granary weevil, all of which are cosmopolitan insects and occur abundantly in different parts of the United States. The preliminary work consisted in the examination of the Argentine grain, the determination of the different species, and the study of conditions and methods, especially with regard to handling at the port of New York. Certain shipments from Argentina show a damage of from 20 to 30 per cent by the various weevils. One species has been found which may possibly be new to this country.

During the year practical experiments were made, on both small and large scales, in the use of gases or fumigants. Of these, dichlorobenzene was thoroughly tested against various stored-product insects, such as weevils, beetles, and moths, and against ants, cockroaches, and other household pests. This gas possesses the value of being neither inflammable nor explosive, so far as could be determined, and it is not injurious to man or domestic animals when inhaled. Various grains, seeds, etc., after fumigation with this substance, have been taken directly from the fumigating house and fed to domestic animals with no harmful results.

Additional observations on the practical use of hydrocyanic-acid gas have been made, and various facts have been ascertained which were previously unknown.

A heating machine, for the destruction of insects in beans, peas, and other seeds, has also been perfected.

#### INVESTIGATIONS OF TROPICAL AND SUBTROPICAL FRUIT INSECTS.

The investigation of insects injurious to tropical and subtropical fruits is under the direction of Mr. C. L. Marlatt.

*Hydrocyanic-acid gas investigations.*—The investigation of the use of hydrocyanic-acid gas for fumigating citrus trees in southern California during the season of 1913-14 has brought this work to practical completion in so far as the main problem is concerned, and a bulletin giving revised practical directions for such fumigation has been prepared and is ready for publication.

Certain citrus insects can not always be satisfactorily controlled by fumigation, and the field force hitherto charged with fumigation experiments has taken up the subject of the control of these and other citrus pests by spray methods as an alternative to the gassing process. The headquarters for this investigation were transferred July 1, 1914, from Whittier, Cal., to Pasadena, Cal.

*The citrus white fly.*—As indicated in the report for last year, the investigation of the citrus white fly in Florida is substantially completed. The educational work, in the way of orchard demonstrations in cooperation with growers in different sections of the State, is in progress.

*Insects affecting date palms.*—The investigation of insects affecting date palms, begun during the preceding year, is still in progress. The annual cycle and life history of the two principal date scale-insect pests will probably be well worked out and completed by the end of 1914, and will be the basis of future control methods.

*Citrus insects in the Louisiana district.*—The investigation of citrus insects, undertaken during the preceding year, is progressing



very satisfactorily. The determination of practical means of control of the Argentine ant in the orchards of New Orleans has been the important work during the year, and it will be possible very soon to present a publication detailing these results.

*Mediterranean fruit fly.*—The investigation of the Mediterranean fruit fly in the Hawaiian Islands, and the control of fruits shipped from these islands to the mainland of the United States, is being conducted in cooperation with the Federal Horticultural Board. The life-history studies of the fruit fly in relation to its many host fruits is approaching completion, and two minor reports have been submitted for publication. Intimate cooperation is maintained with the Territorial board of agriculture of the Hawaiian Islands in the introduction and establishment of parasitic enemies. The quarantine and inspection of fruits is a continuing operation under the Hawaiian fruit fly quarantine. The local clean-up work in the city of Honolulu has been discontinued. The results gained did not warrant the expenditure, and the work operated as an obstacle to the successful introduction and multiplication of parasites.

#### WORK IN BEE CULTURE.

Dr. E. F. Phillips remains in charge of the work in apiculture.

*Wintering of bees.*—The principal work of the year is the continuation of the investigation of bees during the winter. This work, begun in September, 1912, was again carried on during the winter of 1913-14 in the zoological laboratory of the University of Pennsylvania at Philadelphia, Pa., where the bureau had the use of a constant-temperature room, which was used as the beekeeper in the North uses his special bee cellar or repository.

In the work of the year special attention was given to the reduction of heat production to the minimum so that the energies of the bees may be conserved. During the first winter (1912-13) the room was kept at about 43° F., the temperature which is usually considered by beekeepers as the best. Since the early results of this investigation showed that bees generate little heat at temperatures of 57° F. or slightly above, the room temperature was raised to about 57° F. in 1913-14. It was then found that, while heat production was for a time materially reduced, the relative humidity of the room was so decreased that the bees required additional water in some form. A series of experiments was then tried to overcome the harmful conditions due to too low a humidity, and it was found possible to keep the bees in good condition at the higher temperature by supplying moisture.

In the last annual report attention was called to the fact that under certain conditions no heat is produced by the bees and that at lower temperatures the production of heat begins. It has now been possible to formulate this law of heat production more definitely. The results of this part of the work were published during the year in Department Bulletin No. 93, in which it was stated that undisturbed broodless bees generate virtually no heat between 57° and 69° F., while when below the lower critical temperature they generate heat sometimes sufficiently to raise the cluster temperature almost to human blood heat. At higher temperatures the bees move about freely and regulate the temperature of the hive by other means. It has also been shown that this heat is practically all produced by means of muscular activity. Since the length of life of the bee is

determined by the amount of energy expended, it becomes necessary to reduce this muscular activity as much as possible.

A series of observations on colonies out of doors has been carried on for the last two winters, special attention being given to the effects of various kinds and methods of packing and other protection usually employed by beekeepers. It is found that the unprotected single-walled hive often used by beekeepers south of the fortieth degree of latitude and perhaps farther north offers virtually no protection from changes in external temperature during the winter, and that in such a hive an enormous amount of heat production is necessary during cold weather. The giving of additional packing has been found materially to reduce the amount of heat produced.

A special scale for taking weights of a single colony at frequent intervals has been devised for the bureau, and one was purchased in the fall of 1913. By means of this instrument it has been possible to get the hourly changes in weight of one of the colonies in the constant-temperature room. Data of this kind, together with data on the death rate of bees, will be used to determine the differences in the rate of food consumption at different temperatures, correlating these data with the temperature of the cluster. It is too early to give the detailed results of this work.

A general discussion of the winter problem, giving the results of the numerous previous investigations and observations, has been prepared for the purpose of giving beekeepers access to the results. This will be presented for publication in the near future.

*The development of the bee.*—The work on the development of the bee, which has been carried on for some time, has been entirely completed, and forms probably the most extensive study so far made on the embryology of any insect. The work includes a special study of the development of the nervous system, which helps to solve one of the most disputed points in insect embryology.

*The activities of bees.*—Continuing the policy of laying a firm foundation for practical manipulations of bees by a study of their sense organs and their functions, work on the olfactory sense has been continued. The results of the first part of this work were published in the *Journal of Experimental Zoology* in April, 1914, under the title "The olfactory sense of the honeybee." In brief, the conclusion is that the antennæ play no part in the perception of odors, as is usually believed by entomologists, but that certain pores, named olfactory pores, are the organs of odor perception. These are located on the legs, wings, and other parts of the body.

A study was also made of the dorsal scent gland of the bee, including its structure and function. The description of this organ will soon be published.

*Diseases of bees.*—The principal contribution to the investigation of bee diseases during the year is a paper on the amount of heat necessary to destroy the organisms known to be responsible for bee diseases.

*Effect on bees of spraying fruit trees while in bloom.*—Work on the important problem of the effect on bees of spraying fruit trees while in bloom was begun in the spring of 1914, in cooperation with the Deciduous Fruit Insect Investigations of this bureau. Some interesting results have been obtained and the work will be continued.